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Three-Dimensional High-Resolution Simulations of Compressible Rayleigh-Taylor Instability and Turbulent Mixing

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The results of three-dimensional simulations of compressible Rayleigh-Taylor instability and turbulent mixing in an ideal gas using the piecewise-parabolic method (PPM) (both with and without Navier-Stokes terms representing molecular dissipation) are presented. Simulations with spatial resolutions up to 512^3 are performed. The formation of bubbles and spikes, their subsequent growth and merger, and the evolution of the mean fields towards a stably-stratified equilibrium are observed. The dependence of mixing rates on the dimensionless physical parameters such as the Atwood number at the fluid interface and the degree of compressibility is studied. Two types of convergence studies are presented. The first investigates the Reynolds numbers for which the simulations with molecular dissipation are converged with respect to spatial resolution, and the second investigates whether PPM simulations reproduce fully-resolved PPM simulations with molecular dissipation. Finally, extensive statistical analyses of the data at different times during the evolution are presented, including: 1) spectra as a function of height, and; 2) horizontally-averaged correlations of terms in the kinetic energy, internal energy, and enstrophy density evolution equations. The application of this statistical data to the development and testing of subgrid-scale models appropriate for compressible Rayleigh-Taylor induced turbulent mixing is discussed.

Keywords: Rayleigh-Taylor instability, compressible turbulence, turbulent mixing

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